

Technology Reinvestment Project  
Manufacturing Education and Training

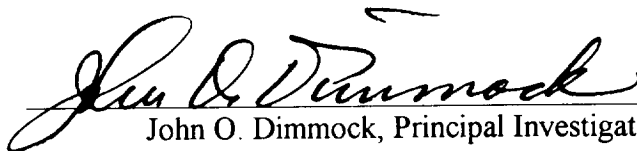
Annual Progress Report

**PRACTICE ORIENTED MASTER'S IN OPTICS**

Center for Applied Optics  
The University of Alabama in Huntsville  
Huntsville, AL

in Collaboration with

Alabama A&M University  
Normal, AL



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March 18, 1996



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## **Brief Abstract**

This award provides support for the development and initial implementation of an interdisciplinary Master's Program with a concentration in Optics and Photonics Technology. This program is a collaboration between the University of Alabama in Huntsville, Alabama A&M University, Northwest Shoals Community College, the NASA Marshall Space Flight Center, the U. S. Army Missile Command, Oak Ridge National Laboratory, the National Institute for Standards and Technology, Advanced Optical Systems Inc., Dynetics, Inc., Hughes Danbury Optical Systems, Inc., Nichols Research Corp., SCI Inc., and Speedring Inc. These organizations have been participating fully in the design, development and implementation of the program. This program is directed at both traditional students as well as government and defense workers who desire specialty education in practical optics and optical systems design and manufacturing. It is intended to produce highly trained graduates who can solve practical problems, and includes an on-site practicum at a manufacturing location.

The broad curriculum of this program emphasizes the fundamentals of optics, optical systems manufacturing and testing, and the principles of design and manufacturing-to-cost for commercial optical products.

The degrees offered are the MS in Physics and the MSE in Electrical Engineering with concentration in Optics and Photonics Technology through the Physics and Electrical and Computer Engineering departments of UAH with support from and in consultation with the Steering Committee composed of representatives from each of the participating organizations plus a student representative.

## **1. Introduction**

An interdisciplinary Master's Program with a concentration in Optics and Photonics Technology is offered under the U.S. Manufacturing Education and Training Activity of the Technology Reinvestment Project (TRP).

A number of industries, government and academic organizations are participating fully in the design, development and implementation of this program. The program will produce highly trained graduates who can solve practical problems. It includes an on-site practicum at a manufacturing location.

The program is designed to enable full-time students and the government and industrial defense work force to transition to commercial manufacturing, enhancing their competitiveness in the global marketplace, and to expand the U. S. job base and economy. The broad spectrum curriculum of this program emphasizes the fundamentals of optics, optical systems manufacturing and testing, and the principles of design and manufacturing to cost for commercial products. The



participating organizations are providing extensive personnel and laboratory facilities to ensure successful implementation and sustainment of the program.

The MS in Physics and MSE in Electrical Engineering Degrees with concentration in Optics and Photonics Technology are offered by the respective University of Alabama in Huntsville (UAH) academic departments under the auspices of the UAH Graduate School, with support from and in consultation with the Steering Committee chaired by Dr. John O. Dimmock, Director of the Center for Applied Optics. The Committee is composed of representatives from each of the participating academic and industrial organizations, as well as a student representative from UAH.

The degree consists of thirty-three credit hours, of which twenty-seven are classroom hours in new and existing courses offered by UAH and Alabama A&M University (AAMU), and six credit hours consisting of a practicum and thesis to be executed at one of the on-site locations.

## **2. Activities and Deliverables**

### **a. Current and Completed Project Activities**

Table 2 summarizes the project activities and deliverables for this reporting period. Four new courses were developed:

1. Optomechanical Design and Manufacturing was developed and taught by Dr. Anees Ahmad and Mr. Darell Engelhaupt during the spring semester last year with four students completing the course. The class is currently being taught this spring.
2. Optics and Photonics Systems Design was developed and taught by Dr. Mustafa Abushagur in the spring semester last year with eight students completing the course. This class is also being taught this spring.
3. Optical Testing and Fabrication was developed and taught by Dr. Lloyd Hillman in the fall semester with five students completing the course.
4. Integrated Product and Process Design was developed and taught by Dr. Phil Farrington in the fall semester with seventeen students completing the course.

Dr. Don Gregory and Dr. Gregory Nordin supervise two students, Paul Burke and Jeff Meier, who began work on their practicums at NASA/Marshall Space Flight Center the beginning of summer, 1995.

In addition to these curriculum and training tasks, the following significant activities were also accomplished:





1. The program was highlighted at a booth which was acquired by UAH at the 11th Annual Technical and Business Exhibition and Symposium held at the von Braun Civic Center on May 16 - 17, 1995. The symposium was attended by over 5,000 individuals and many picked up materials available at the booth describing the program. Materials associated with this were included with the 3/19/95 - 6/18/95 Quarterly Report.
2. A meeting to review the first year of the program was held with the students on May 24, 1995. The students reported that the program was going well and that they were looking forward to their summer practicum experiences. One recommendation was that it would be useful if a single practical design and fabrication problem could be identified at the start of the program and carried through all of the core classes. This recommendation was passed on to the faculty who are attempting to incorporate it into the 1995-1996 curriculum.
3. An invited talk on the program was presented at the 1995 International Conference on Education in Optics associated with the Annual Meeting of the International Society for Optical Engineering on July 10, 1995. The manuscript is attached to the 3/19/95-6/18/95 Quarterly Report. This paper has been published in the proceedings of the conference, SPIE Proceedings Volume 2525, paper 35, pgs 370 - 378. A second presentation the program was given at the Optical Society of America Forum on Education and included in the proceedings of this conference as well. These two papers are essentially identical.
4. An additional nine students entered the program in August and two scholarships were provided with project funds.
5. Meetings were held with each student in the program and with all students collectively to discuss the program requirements and objectives and the needs and interests of the individual students as well as their plans for completion. The principal issue was the lack of availability of all required courses in the evening for students with full time jobs. This remains an issue as most of the students prefer the current schedule where most of the required courses are available during the day.
6. A significant amount of advertising has gone out. Program fliers have been sent to 140 campus chapters of the Optical Society of America and the Society of Physics Students, and 98 fliers were sent to companies working in optics and photonics technologies. See Attachment 1. Further the availability of the program and financial aid was included on the UAH web site with links to the NSF/MET site as well as the web sites of the optics and photonics professional societies.
7. The Second Annual Review of the program was held on March 6, 1996. Attachment 2 is a copy of the agenda, attendee list and presentation materials. There was substantial discussion following the student presentation by Paul Burke, the student representative on the steering committee. The students indicated that the program would benefit by having more opportunities for laboratory work and by having more of the courses available in the evening.



These recommendations will be addressed by the faculty during the next reporting period. Further it was determined that the students were not sufficiently familiar with the courses offered under the program by Alabama A&M University. A visit to that campus is planned to rectify this situation.

**b. Activities Planned or Begun for the Next Reporting Period**

1. Faculty committees have been established for five of the new students and will be established for the remaining four in the next reporting period.
2. Practicum activities for some of the second class have been initiated and will begin for the rest of the students this summer.
3. The student issues noted in subparagraph 7 above will be addressed by the program faculty in consultation with the students.
4. The visit to Alabama A&M University campus, noted above, has been scheduled for March 20, 1996.

**3. Commitment to Education**

Under this program a new concentration option under the Master's of Science (Physics) and Master's of Science in Engineering (Electrical Engineering) degree programs of the University of Alabama in Huntsville was developed and approved by the Alabama Commission of Higher Education of The University of Alabama System. This concentration consists of courses offered by the University of Alabama in Huntsville and by Alabama A&M University in Normal, Alabama. It includes four new courses, as described in section 2 of the annual report for 1994-1995, focussing on practical optics design and manufacturing and on manufacturing management. It is our opinion that the combination of fundamental optical science, design and manufacturing, and manufacturing management offered under this concentration is unique. It is expected that this concentration will fully prepare students for leadership roles in practical optics and photonics manufacturing of both military and commercial products.

To date there are only two "manufacturing workforce" students in the program even though considerable effort was expended in advertising the program broadly throughout the optics commercial and defense industrial base. We have extensively advertised this opportunity to this community for the fall of 1996 matriculation. In addition to mailing flyers we have strongly encouraged the industrial and government members of the Steering Group to encourage their employees to consider this opportunity. It is, of course, too early at this time to assess the results of these efforts. Although the two working students have indicated a desire to have more of the courses available in the evening, and we intend to address that, we have not gotten the indication that course schedule has been a deterrent to prospective students.



The University of Alabama in Huntsville has supported two students in this concentration with assistantships. The program is fully multi-disciplinary, involving courses developed and offered by the Physics, Electrical and Computer Engineering, and Industrial and Systems Engineering Departments, the Optical Science and Engineering program and the Center for Applied Optics. Establishing this multi-disciplinary program was possible only through the establishment of teamwork and partnerships across these disciplines as well as between institutions and private and public sectors. The outcomes are currently being implemented and tested. They will be assessed and disseminated in the next two periods of the program.

#### **4. Innovativeness**

This multi-disciplinary concentration is new at the University of Alabama in Huntsville and we believe in the United States. The coursework includes fundamental optical science, practical optics and photonics design, fabrication, testing and manufacturing, and manufacturing management. Several of the courses include hands-on activities and the onsite practicum involves project work at industrial and government locations.

Educational materials used in the four new courses, in particular, deal directly with optical and photonic systems design fabrication, test, evaluation and manufacturing as well as manufacturing management. All of the new courses as well as the curriculum as a whole have been developed with industrial involvement and with the approval of the Steering Committee which has a strong industrial flavor. Industrial experts are involved in the development and delivery of all of the new courses offered in this concentration.

#### **5. Target Populations**

Information has been distributed several times as follows: Through the Alliance for Optical Technology to Government and defense workforce; graduating seniors locally (UAH, AAMU, Oakwood College) and nationwide; and to student chapters of the Optical Society of America. A brochure and admission form is sent to each prospective student who inquires.

Alabama A&M University, an Historically Black University, has been involved in this program from the initial planning stage. Several of the courses offered in this concentration are given at Alabama A&M, and a representative of Alabama A&M sits on the Steering Committee and contributes to the program guidance. Historically Black and Minority Institutions in the southeast which have Dual Degree Programs with UAH have been particularly targeted in our advertising campaign.

#### **6. Resources - Leadership, Management, and Team**



The project team consists of a balanced mix of faculty and industrial personnel. The names, affiliations and areas of expertise of the **key** project team members are listed as follows:

***Key Project Faculty:***

<b>Name</b>	<b>Department</b>	<b>Areas of expertise</b>
1. Dr. John Dimmock	Center for Applied Optics	Solid State Physics
2. Dr. Anees Ahmad	Center for Applied Optics	Optomechanical Engr'g
3. Dr. Mustafa Abushagur	Electrical Engineering	Optical Signal Processing
4. Dr. Llyod Hillman	Physics	Lasers and Quantum Elec.
5. Dr. Phillip Farrington	Industrial Engineering	Mfg. Systems and QC

***Key Industrial Personnel:***

<b>Name</b>	<b>Industry</b>	<b>Areas of expertise</b>
1. Dr. Robert Berinato	Dynetics, Inc.	Electro-optics
2. Mr. Philip Stahl	Hughes Danbury	Optical Fab and Testing

A much larger group of faculty, industry and government personnel are members of the Steering Group as shown on Attachment 3.

The overall program is guided by the Steering Group described above. The program development and management is provided by the Faculty Committee.

## **7. Resources - Equipment, Facilities, and Teaching/Learning Laboratories**

The labs used in this program are housed in our 110,000 square foot optics building which was specifically designed for state-of-the-art optics research. It contains four floors of vibrationally-isolated and environmentally-shielded lab core, which includes over 6,000 square feet of cleanroom space.

The labs currently being used are the Virtual Prototyping Laboratory and the Optical Design Laboratory. A variety of capabilities exist to perform virtual prototyping of complex off-axis aspheric optical systems, direct transfer of optical ray traces and surfaces to AutoCAD Finite Element Analysis (FEA) programs, and CNC machines for optical parts fabrication. Software





includes: AutoCAD release 13 with AME (Advanced Modeling Extension) capability, mechanical fasteners and geometric dimensioning and tolerancing symbols libraries, Autospell and a text editor. Hardware includes 486 and Pentium computers and a Hewlett-Packard Draftpro EXL color pen plotter (A-E size). The Optical Design Laboratory contains the best commercial optical design programs (CODE V, SYNOPSYS, and others), in addition to a unique link to CAD and Finite Element Analysis, resulting in the ability to:

- 1) design leading-edge optical systems with tolerancing and fabrication specifications;
- 2) download to CAM; and
- 3) optimize the optical systems for manufacturability and performance.

## **8. Resources - Budget**

With the completion of the initial new course development, the faculty have not been charging all of their class and preparation time but have been considering a large portion of this time as cost sharing to the contract, thus freeing up funds to support students and some travel. The result of this is that we had not spent all of the money in the second year of the contract that was planned, and we will carry this over into the following year enabling us to support additional students in the program. Funds were expended for salaries, student support and advertising the program in national magazines as well as group mailings of literature developed for the program.

The cost sharing for the second year was 2.07 of the TRP award expended. Personnel from Dynetics prepared and delivered four lectures for EE 570 and EE 670 courses, prepared practicum opportunities and served on the Steering Committee. Nichols also prepared practicum opportunities to be available to POMO students. NASA/MSFC provided stipend, personnel and facilities for two students to do their practicum.

## **9. Industrial Involvement**

Tables 6 and 7 indicate the industrial involvement in the program. The involvement has been through the overall program development and guidance provided by the Steering Group, the industrial participation in the course development and delivery, and the support through the on-site practicum opportunities. Firms involved include both small business and large business as well as both defense and commercial businesses.

## **10. Assessment**

This program is under continuous assessment by the Steering Committee which includes a student representative. The Steering Committee review on March 6, 1996 evaluated the program progress in its second year. It was felt that the program is generally meeting its objectives



although we hope that the number of students, particularly those in industry, could be increased. The students in the program are generally pleased with the course work and schedule except in the areas of laboratory involvement and evening alternative class scheduling. These issues will be addressed as noted above. We are disappointed that it has taken considerably longer for the two original students to complete their practicum projects and graduate than originally expected. However, the students themselves do not appear to be as concerned. The projects undertaken have turned out to be more substantial than originally thought. In hindsight this should not have been a surprise. We will need to counsel incoming students to expect two years for their degree rather than the sixteen months originally budgeted. Further assessments are planned for September 1996 and February 1997. Assuming that we get another increase in students comparable to that experienced this last year, the program should be self sustainable at that time with the possible exception of stipends for students. This will be addressed in the next year of the program. We will also, of course, track the graduates to follow their career progress after graduation and compare it with other UAH MS and MSE graduates in Physics and Electrical Engineering during the same period to assess overall program success.

**11. Current Research Support of Senior Personnel**

This project is monitored by the NASA Marshall Space Flight Center.

**12. Animal Care and Use, Institutional Biohazard Committee and Human Subject Certification**

Not applicable.

**13. Other Significant Information**

None.

**14. Attachments**

Attachment 1: Flier

Attachment 2: March 6 Meeting

Attachment 3: Steering Group



# TABLES



**Table 1**  
**Background Information**

<u>Function</u>	<u>Name</u>	<u>Phone</u>	<u>Fax</u>	<u>E-Mail</u>
Principal Investigator	Dr. John O. Dimmock	205 895-6030, 400	205 895-6618	dimmockj@email.uah.edu
Technical Leader (if not PI)				
Database Contact	Freya W. Bailey	205 895-6030, 474	205 895-6618	baileyf@email.uah.edu

Name		Updated 2/17/95
Home Institution	State	Data Collected
		From <input type="text"/> Through <input type="text"/>
Headquarters' Address		
HQ Phone	HQ Fax	





Table 2

Project Activity Summaries

Project Title	Lev.	Investigator	Site	Test	Impl.	Del	Description
On-Site Practicum & Thesis	<input type="checkbox"/> T <input type="checkbox"/> L <input type="checkbox"/> U <input type="checkbox"/> A <input checked="" type="checkbox"/> G <input type="checkbox"/> P <input type="checkbox"/> O	Dr. D. Gregory Dr. G. Nordin		<input checked="" type="checkbox"/> Yes <input type="checkbox"/> No	<input checked="" type="checkbox"/> Yes <input type="checkbox"/> No <input type="checkbox"/> Cont.	<input type="checkbox"/> M <input type="checkbox"/> C <input type="checkbox"/> W <input type="checkbox"/> Y <input type="checkbox"/> D <input type="checkbox"/> S <input type="checkbox"/> I <input checked="" type="checkbox"/> XT <input type="checkbox"/> O	Two students are nearing completion of their practicum at NASA/MSFC.
Optomech. Design and Manufacturing Course	<input type="checkbox"/> T <input type="checkbox"/> L <input type="checkbox"/> U <input type="checkbox"/> A <input checked="" type="checkbox"/> G <input type="checkbox"/> P <input type="checkbox"/> O	Dr. A. Ahmad		<input checked="" type="checkbox"/> Yes <input type="checkbox"/> No	<input checked="" type="checkbox"/> Yes <input type="checkbox"/> No <input type="checkbox"/> Cont.	<input type="checkbox"/> M <input checked="" type="checkbox"/> C <input type="checkbox"/> W <input type="checkbox"/> Y <input type="checkbox"/> D <input type="checkbox"/> S <input type="checkbox"/> I <input type="checkbox"/> T <input type="checkbox"/> O	Course was developed and offered for the first time in Spring 1995 semester. Four students successfully completed the course.
Optics and Photonics Systems Design	<input type="checkbox"/> T <input type="checkbox"/> L <input type="checkbox"/> U <input type="checkbox"/> A <input checked="" type="checkbox"/> G <input type="checkbox"/> P <input type="checkbox"/> O	Dr. M. Abushagur		<input checked="" type="checkbox"/> Yes <input type="checkbox"/> No	<input checked="" type="checkbox"/> Yes <input type="checkbox"/> No <input type="checkbox"/> Cont.	<input type="checkbox"/> M <input checked="" type="checkbox"/> C <input type="checkbox"/> W <input type="checkbox"/> Y <input type="checkbox"/> D <input type="checkbox"/> S <input type="checkbox"/> I <input type="checkbox"/> T <input type="checkbox"/> O	Course covers Optoelectronic Components, Subsystems & Systems Eight students successfully completed the course.
Optical Testing and Fabrication	<input type="checkbox"/> T <input type="checkbox"/> L <input type="checkbox"/> U <input type="checkbox"/> A <input checked="" type="checkbox"/> G <input type="checkbox"/> P <input type="checkbox"/> O	Dr. L. Hillman		<input checked="" type="checkbox"/> Yes <input type="checkbox"/> No	<input checked="" type="checkbox"/> Yes <input type="checkbox"/> No <input type="checkbox"/> Cont.	<input type="checkbox"/> M <input checked="" type="checkbox"/> C <input type="checkbox"/> W <input type="checkbox"/> Y <input type="checkbox"/> D <input type="checkbox"/> S <input type="checkbox"/> I <input type="checkbox"/> T <input type="checkbox"/> O	Fabrication Testing & Coating of Optical Coatings Five students successfully completed the course.



Table 2

## Project Activity Summaries

Project Title	Lev.	Investigator	Site	Test	Impl.	Del	Description
Integrated Product and Process Design (IPPD)	<input type="checkbox"/> T <input type="checkbox"/> L <input type="checkbox"/> U <input type="checkbox"/> A <input checked="" type="checkbox"/> G <input type="checkbox"/> P <input type="checkbox"/> O	Dr. P. Farrington		<input checked="" type="radio"/> Yes <input type="radio"/> No	<input checked="" type="radio"/> Yes <input type="radio"/> No <input type="radio"/> Cont.	<input type="radio"/> M <input checked="" type="radio"/> C <input type="radio"/> W <input type="radio"/> Y <input type="radio"/> D <input type="radio"/> S <input type="radio"/> I <input type="radio"/> T <input type="radio"/> O	Concepts & tools for IPPD Life-Cycle Engr'g & Real Product Programs 17 students successfully completed the course.
	<input type="checkbox"/> T <input type="checkbox"/> L <input type="checkbox"/> U <input type="checkbox"/> A <input type="checkbox"/> G <input type="checkbox"/> P <input type="checkbox"/> O			<input type="radio"/> Yes <input type="radio"/> No	<input type="radio"/> Yes <input type="radio"/> No <input type="radio"/> Cont.	<input type="radio"/> M <input type="radio"/> C <input type="radio"/> W <input type="radio"/> Y <input type="radio"/> D <input type="radio"/> S <input type="radio"/> I <input type="radio"/> T <input type="radio"/> O	
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Table 3: Personnel

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Table 3: Personnel

Personnel Classification	Total	Sex		US	Race/Ethnicity						Foreign	Disabled
		F	M		NA	AA	C	H	PI	A		
Students Doing Internships in Industry	These were students in the summer internship summer of '96- listed in above statistics 3	1	2	3			2			1		
Active Defense Workers	2	1	1	2			2					
Displaced Defense Workers												

Race/Ethnicity for U.S. citizens and permanent residents only: (NA) Native American; (AA) African American, not of Hispanic origin; (C) Caucasian, not of Hispanic origin; (H) Hispanic; (PI) Pacific Islander; (A) Asian.





Table 4: Functional Expenditures

Functional Category	Current Year
Faculty Salaries	\$21,756
Student Salaries	\$ 5,814
Research Staff Salaries (Full-time (non-teaching) research scientists and technical support)	\$ 337
Post-Doc Salaries	
Administration Management Salaries (clerical support, contracts officer, etc.)	\$13,429
Other Salaries	
General Operating Expenses	\$ 3,888
Facilities	
Travel	\$ 989
Equipment	
University Overhead-Indirect Costs	\$19,770
<u>Total</u>	\$65,983



**Table 5: Matching Funds by Source of Support**

<u>Type</u>	<u>TRP/MET Award</u>	<u>Industry</u>	<u>Univ.</u>	<u>Other Federal Agencies</u>	<u>State</u>	<u>Other Support</u>	<u>Total</u>
Cash-Unrestricted							
Cash-Restricted	65,983						65,983
In-Kind Equipment, Materials and Supplies							
In-Kind Personnel		15,837	97,127	14,492			127,456
In-Kind Software							
Other							
STUDENTS TUITION			6,625 2,557				6,625 2,557
Total	65,983	15,837	106,309	14,492			202,621



Table 6: Industrial Participation

Company	Type of Support			Part.	Size	Foreign Representative(s)	Hire or Supervise	Engineering Production	Remarks
	CA	SE	IP	A	S				
Dynetics	<input type="checkbox"/>	<input type="checkbox"/>	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	<input type="checkbox"/> Yes <input checked="" type="checkbox"/> No	<input checked="" type="checkbox"/> H <input type="checkbox"/> S <input type="checkbox"/> N	<input checked="" type="checkbox"/> Yes <input type="checkbox"/> No <input type="checkbox"/> Unkn	Dr. Berinato delivered 4 lectures for EE 570 and EE 670 courses, and also served on the Steering committee.
	<input checked="" type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>				
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Nichols	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input checked="" type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/> Yes <input checked="" type="checkbox"/> No	<input checked="" type="checkbox"/> H <input type="checkbox"/> S <input type="checkbox"/> N	<input checked="" type="checkbox"/> Yes <input type="checkbox"/> No <input type="checkbox"/> Unkn	Served on the Steering committee of the program and provided information about practicum opportunities at Nichols.
	<input checked="" type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input checked="" type="checkbox"/>				
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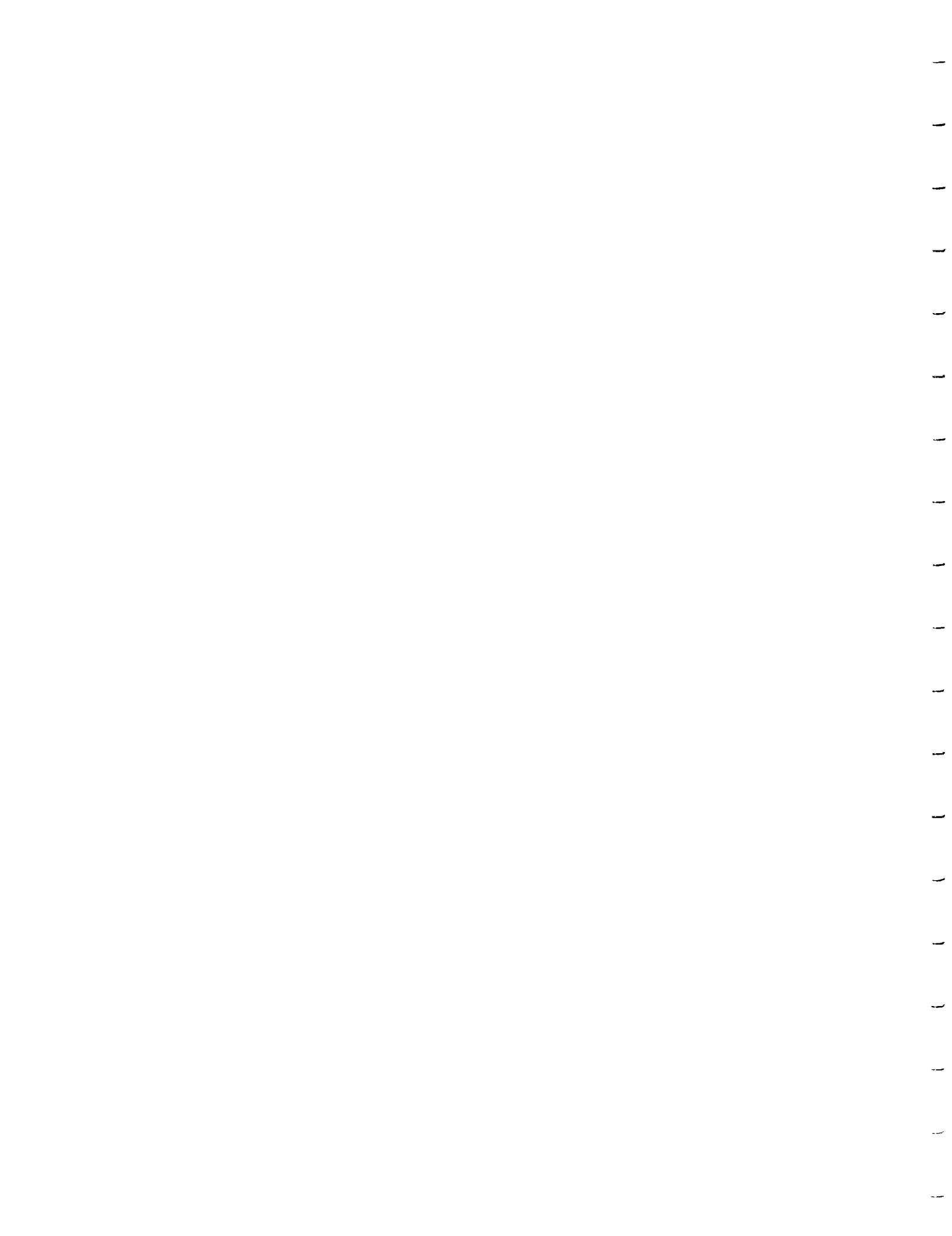
### Table 7: Non-Industrial Participation

Organization	Type of Support	Type of Part.	Size	Foreign Representative(s)	Hire or Supervise	Engineering Production	Remarks
NASA/MSFC	<input checked="" type="checkbox"/> CA	<input checked="" type="checkbox"/> SE	<input checked="" type="checkbox"/> A	<input type="checkbox"/> S	<input type="checkbox"/> Yes	<input checked="" type="checkbox"/> H	<input checked="" type="checkbox"/> Yes
	<input checked="" type="checkbox"/> IP	<input type="checkbox"/> OS	<input checked="" type="checkbox"/> F	<input type="checkbox"/> M	<input type="checkbox"/> No	<input type="checkbox"/> S	<input type="checkbox"/> No
	<input type="checkbox"/> IE	<input type="checkbox"/> NA	<input type="checkbox"/> L	<input checked="" type="checkbox"/> L	Jim Bilbro	<input type="checkbox"/> N	<input type="checkbox"/> Unkn
	<input type="checkbox"/> IS						
	<input type="checkbox"/> CA	<input type="checkbox"/> SE	<input type="checkbox"/> A	<input type="checkbox"/> S	<input type="checkbox"/> Yes	<input type="checkbox"/> H	<input type="checkbox"/> Yes
	<input type="checkbox"/> IP	<input type="checkbox"/> OS	<input type="checkbox"/> F	<input type="checkbox"/> M	<input type="checkbox"/> No	<input type="checkbox"/> S	<input type="checkbox"/> No
	<input type="checkbox"/> IE	<input type="checkbox"/> NA	<input type="checkbox"/> L	<input type="checkbox"/> L		<input type="checkbox"/> N	<input type="checkbox"/> Unkn
	<input type="checkbox"/> IS						





# **ATTACHMENT 1**



A Practice Oriented Master's Degree Program in

# Optics & Photonics Technology

Colleges of  
Engineering  
& Science

**UAH**  
The University of Alabama in Huntsville

Colleges of  
Engineering  
and Science

## Introduction

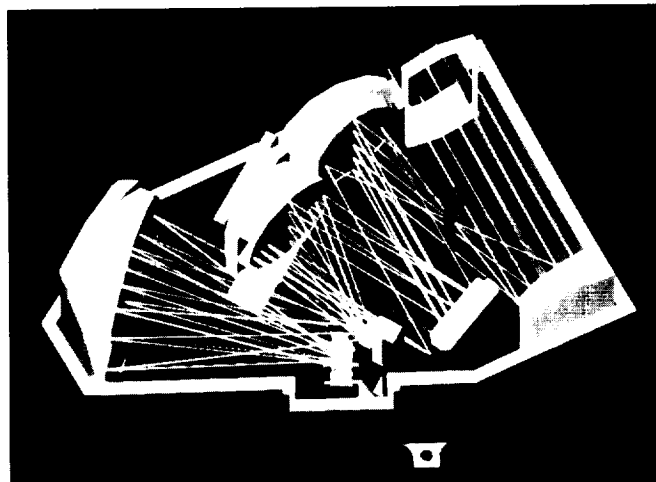
A unique, industry-oriented interdisciplinary Master's degree program with a concentration in optics and photonics technology is being offered at The University of Alabama in Huntsville under the U.S. Manufacturing Education and Training Activity of the Technology Reinvestment Project.

A large number of industries, government and academic organizations have participated in designing, developing and implementing this program to produce highly-trained graduates who can solve practical problems. It includes an on-site practicum at a manufacturing location.

The program is designed to enable full-time students, and the government and industrial defense work force to transition to commercial manufacturing, enhancing their competitiveness in the global marketplace, and to expand the U.S. job base and economy. Some distinguishing features of this program include:

- A mix of science, engineering and management courses;
- Applications-oriented courses with design and hands-on laboratory content; and
- An on-site practicum at an industry or government research laboratory.

The program emphasizes the fundamentals of optics, optical systems manufacturing and testing,



*A 3-D model of a compact imaging spectrometer developed at UAH*

and the principles of design and manufacturing to cost for commercial products. Participating organizations provide extensive personnel and laboratory facilities to ensure success.

The program is offered by the Electrical Engineering and Physics departments of The University of Alabama in Huntsville (UAH) under the auspices of the UAH Graduate School.

## Admission Requirements and Financial Aid

\* A bachelor's degree in science or engineering from an accredited institution; plus

\* A minimum average of B (GPA of 3.0) on the undergraduate record; and

\* A minimum score of 1,500 on the aptitude test (verbal, quantitative, and analytical) portion of the GRE.

These are Graduate School requirements. Some departments may require higher averages or additional qualifications. The applicant whose native language is not English is required to take the Test of English as a Foreign Language (TOEFL) and score at least 500.

**Financial aid** is available for all qualified students. Information regarding financial assistance is included with the application material sent to each prospective student.

Further information may be obtained by calling the Center for Applied Optics at (205) 895-6030.

**UAH**  
The University of Alabama in Huntsville

# UAH

The University of Alabama in Huntsville

Colleges of  
**Engineering  
and Science**

**Colleges of  
Engineering  
& Science**

A Practice Oriented Master's Degree Program in  
**Optics & Photonics Technology**

## Curriculum Requirements

- 21 hours of required core courses, including:
- \* 6 credit hours in optics principles;
  - \* 9 credit hours in optical design & manufacturing technology;
  - \* 6 credit hours in engineering management.
- 6 hours in elective courses (two courses to be taken in one of the following areas):
- a. Optical systems and engineering
  - b. Quantum optics
  - c. Optical signals
  - d. Optical communications
  - e. Optical materials
  - f. Manufacturing technology: Systems
  - g. Manufacturing technology: Quality
  - h. Manufacturing technology: Statistics
  - i. Manufacturing technology: Reliability
  - j. Engineering management, integrated production & processes
  - k. Marketing, management and management science
  - l. Physics
- 6 hours of on-site practicum and a thesis.

## Facilities

The focal point of all optics research at UAH is the 118,000-square-foot Optics Building. There are more than 20 advanced optics laboratories in the building. These labs are administered by faculty from the physics, electrical and computer engineering, mechanical and aerospace engineering, and the chemical and environmental engineering departments, as well as researchers from UAH's Center for Applied Optics.

Some of the unique laboratories are:

- Experimental Mechanics and Applied Optics;
- Holography & Speckle Metrology;
- Optical Coatings;
- Optical Design and Modeling;
- Optical Fabrication;
- Optical Information Processing;
- Optical Metrology;
- Opto-electronics Research;
- System Prototyping; and
- Virtual Prototyping.

The following laboratories at Alabama A&M University are also available:

- Crystal Growth;
- Fiber Optics;
- Glassy Carbon Manufacturing;
- High Temperature Furnace;
- Holography;
- Laser Labs;
- Materials Characterization;
- Materials Irradiation Center;
- Microgravity Space Experiments; and
- Optical In-situ Crystal Growth Rate Measurement.

## Practicum Examples

A number of on-site practicum opportunities are available for the students in the areas of precision optical fabrication; diffractive, binary and coherent optics; optical wave guides; metrology instruments for scatter and figure of aspheric optics; optical image processing; acousto-optic and microwave devices; optical instrumentation for ice detection; laser ranging; remote sensing; cryogenic radiometry; and fiber optic sensors. These practicum are offered at the facilities of the following program affiliates:

- \* NASA/Marshall Space Flight Center
- \* U.S. Army Missile Command
- \* Oak Ridge National Laboratory
- \* National Institute of Standards & Technology
- \* Advanced Optical Systems
- \* Dynetics, Inc.
- \* Hughes Danbury Optical Systems, Inc.
- \* Nichols Research Corporation
- \* SCI Systems, Inc.
- \* Speedring, Inc.

## For more information, please contact:

**Dr. John O. Dimmock, Program Director**  
Center for Applied Optics  
University of Alabama in Huntsville  
Huntsville, AL 35899  
Phone: (205) 895-6030, Ext. 400  
FAX: (205) 895-6618  
E-mail: dimmockj@email.uah.edu

# **ATTACHMENT 2**



**MS/MSE Concentration in Optics and Photonics Technology**  
**Second Annual Program Review, March 6, 1996**  
**UAH Optics Building, Room 234**

**Agenda**

9:15	Coffee	
9:30	Introduction and Overview	Dimmock
9:40	Optical and Photonics System Design	Abushagur
9:50	Optomechanical Design and Mfg.	Ahmad
10:00	Optical Fabrication and Testing	Hillman
10:10	Integrated Production and Process Design	Farrington
10:20	Practicum Report	Burke
10:40	Practicum Report	Meier
11:00	Students Perspective (discussion)	Burke
11:15	Alabama A&M Overview	Lal
11:30	Industry Perspective	Berinato
11:45	Summary, Discussion, Actions	Dimmock
12:00	Adjourn	





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# **MS in Physics / MSE in Electrical Engineering with concentration in Optics and Photonics Technology**

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**Funded under the Technology Reinvestment Project.  
Industry, Academic and Government Organizations.**

## **Mix of**

- Δ Optics Principles**
- Δ Design and Manufacturing Technology**
- Δ Practical Manufacturing Management**

**Including an On-Site Practicum at a Manufacturing Location**



# **MS/MSE Concentration in Optics and Photonics Technology**

## **Project Team**

### **Academic Institutions**

University of Alabama in Huntsville  
Alabama A&M University  
Northwest Shoals Community Coll.

### **Government Institutions**

NASA Marshall Space Flight Ctr.  
U.S. Army Missile Command  
Oak Ridge National Laboratory  
Nat'l Institute of Standards & Tech.

### **Industrial Affiliates**

Advanced Optical Systems  
Dynetics Inc.  
Hughes Danbury Optical Sys.  
Nichols Research  
SCI Inc.  
Speedring, Inc.

### **Advisory**

Space & Systems Defense Cmd.  
Boeing Defense & Space Group  
Mason and Hanger Nat'l.  
Morgan Research  
Teledyne Brown Engineering  
WIT, Inc.



# Curriculum Requirements

## 21 Hours Required Core Courses

- 6 credit hours in Optics Principles
- 9 credit hours in Optics Design and Manufacturing Technology
- 6 credit hours in Engineering Management

## 6 Hours Required in Elective Courses (two courses to be taken in one of the following lettered areas)

- a. Optical Systems and Engineering
- b. Quantum Optics
- c. Optical signals
- d. Optical Communications

- e. Optical Materials
- f. Manufacturing Technology, Systems
- g. Manufacturing Technology, Quality
- h. Manufacturing Technology, Statistics
- i. Manufacturing Technology, Reliability
- j. Physics
- k. Engineering Management
- l. Marketing/Management/Management Science

**6 Hours of On Site Practicum and Thesis required**





# **MS in Physics/MSE in Electrical Engineering with concentration in Optics and Photonics Technology Program**

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Required Core Course: (21 hours)

Optical Principles: ( 6 hours)

Geometrical Optics (OSE 541 - UAH or PHY 649 - AAMU)

Physical Optics (OSE 542 - UAH or PHY 657 - AAMU)

Optical Design and Manufacturing Technology ( 9 hours)

Optics and Photonics System Design (EE 570 - UAH)

Optomechanical Design and Manufacturing (EE 670 - UAH)

Optical Fabrication and Test (OSE 654 - UAH)

Engineering Management ( 6 hours)

Integrated Production and Process Design (ISE 570 - UAH)

Engineering Management Elective



# Optics and Photonics Systems Design

**Textbook:** Saleh and Teich, *Fundamentals of Photonics*

**Course Outline:**

## 1. Components

- 1.1 Light Sources
- 1.2 Detectors
- 1.3 Modulators
- 1.4 Lenses and Mirrors
- 1.5 Diffractive Optical Elements
- 1.6 Fibers and Fiber Components

## 2. Subsystems

- 2.1 Transmitters
- 2.2 Receivers
- 2.3 Detector Arrays, Drive Electronics
- 2.4 Optical Correlators
- 2.5 Post Processing

## 3.

### Systems

- 3.1 Telescopes
- 3.2 Optical Pattern Recognition
- 3.3 Adaptive Signal Processing
- 3.4 Laser Radars
- 3.5 Infrared Systems
- 3.6 Fiber Communication Networks
- 3.7 Fiber Imaging
- 3.8 Fiber Sensors

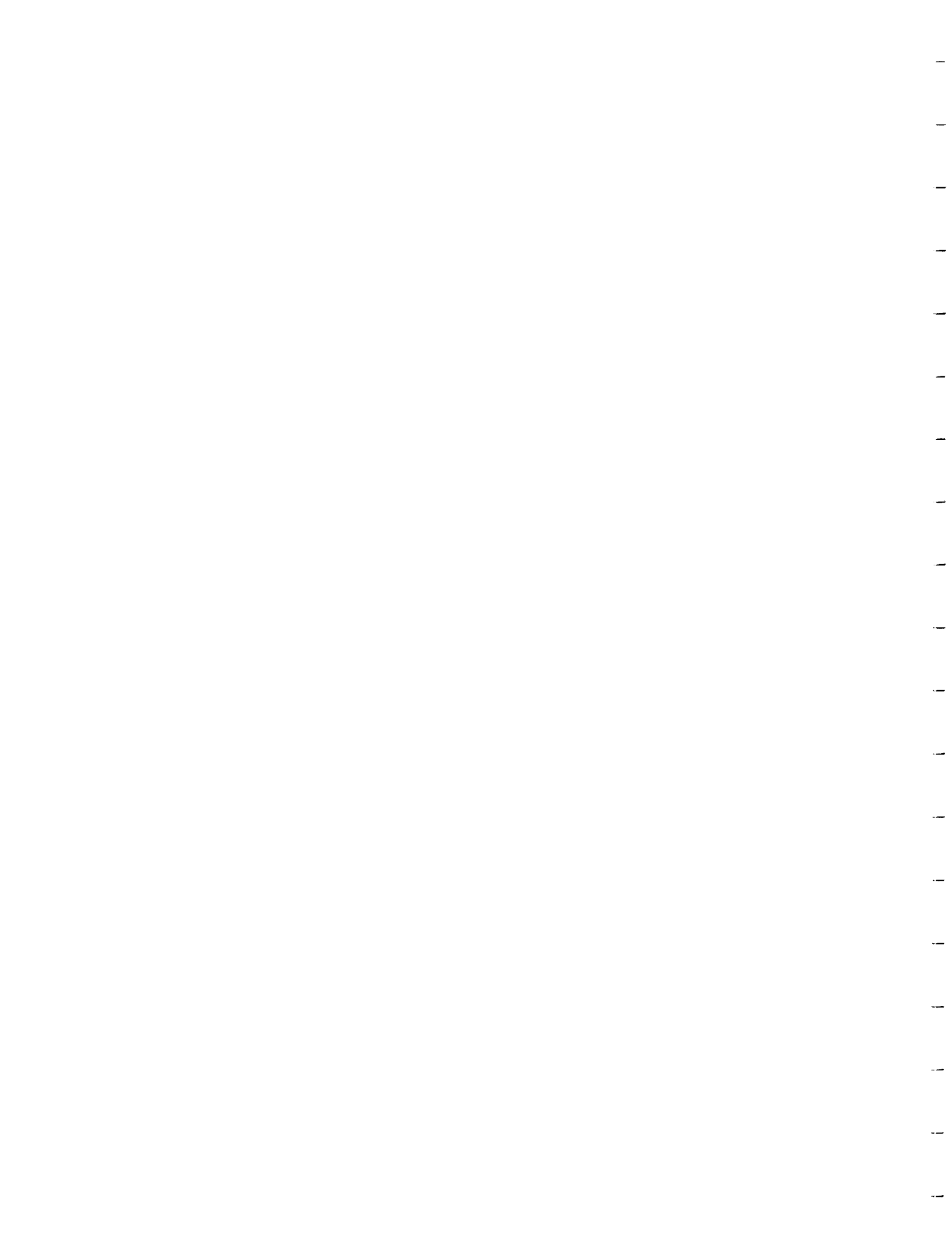


# Optomechanical Design and Manufacturing

**Text:** Yoder, *Optomechanical System Design*

## **Course Outline**

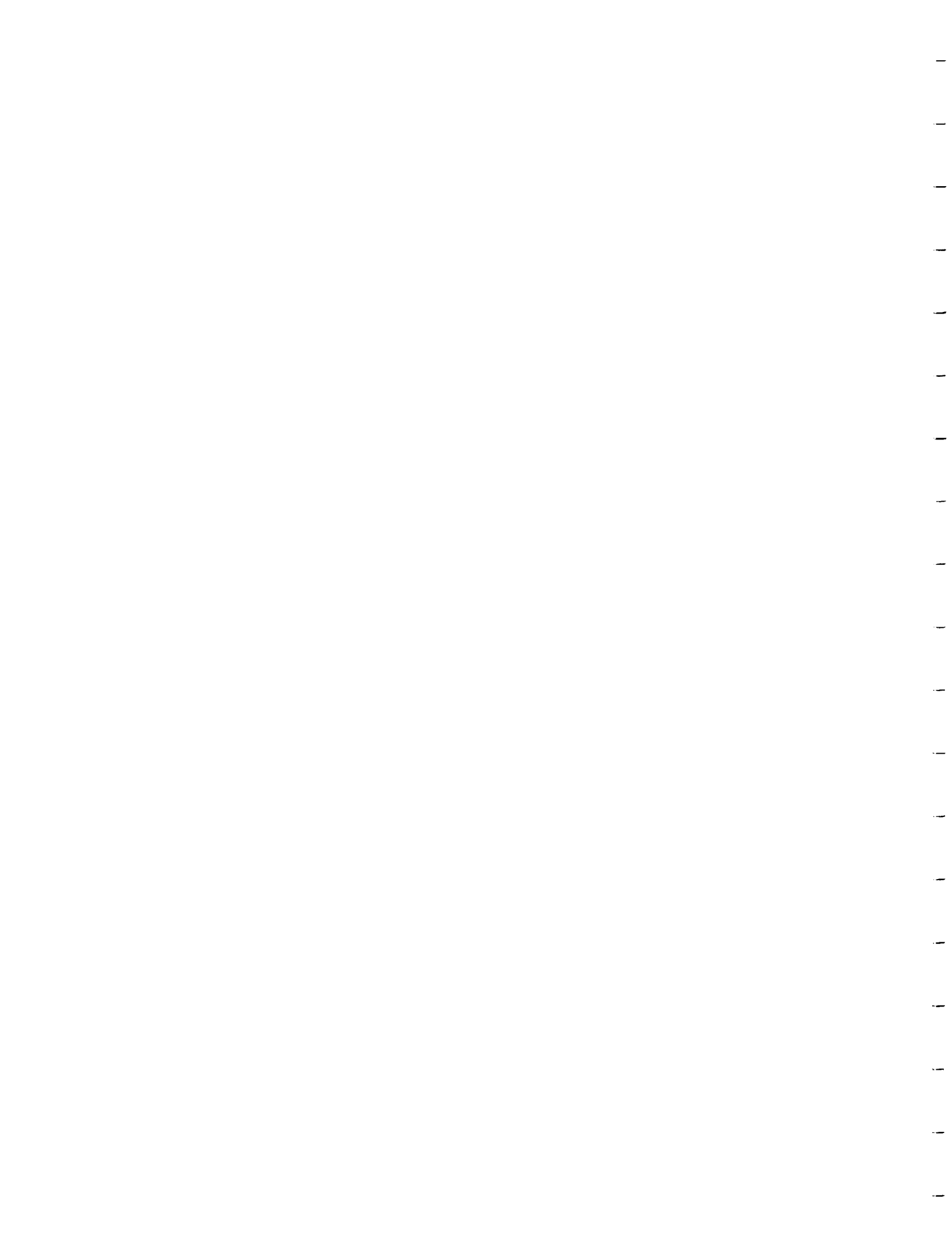
1. Optomechanics fundamentals and CAD
2. Optical mounts for mirrors, lenses, prisms & filters
3. Adjustment mechanisms (linear, tilt and rotary)
4. Dimensional stability, thermal and environmental considerations
5. Material selection for optical and structural parts
6. Fabrication methods (tolerances, machining, HT & chemical processes
7. Advanced topics (IR systems, DM optics, biomedical and environmental monitoring applications, optical methods for non-destructive testing)
8. Computer-aided design and analysis project



# Optical Testing and Fabrication

## Course Outline

1. Optical Bench Measurements Nodal Slide, focal lengths, cardinal points
2. Component measurements Radius of curvature, refractive index, surface roughness
3. General Light Field Measurements
4. Aberrations Wavefront aberrations, transverse aberrations, MTF
5. Geometrical Tests Knife-edge, Hartman, Ronchi
6. Interferometric and Wavefront Tests Fizeau, Twyman-Green, lateral shearing
7. Grinding and Polishing
8. Optical Coatings
9. Remote Optical Diagnostics Holographic interferometry, Moire tests
10. Fabrication and testing techniques of optical components and systems
11. Component measurements
12. Lecture and "*Hands-on*" Laboratory Grind and polish 8" f/10 mirror Test with WYCO, ZYGO, Foucault Reflective Coating





# Integrated Product and Process Design

Texts: Pugh, *Total Design*  
K Katzenbach and Smith, *The Wisdom of Teams*

## Course Outline:

1. Introduction to the IPPD philosophy
2. Managing the Change to IPPD
3. Building Effective teams
4. Managing Multi-Functional Teams
5. Designing for Performance
6. Computer Aided Engineering & Test Considerations
7. Design for Manufacturability
8. Design for Reliability & Serviceability
9. Design for Testability
10. Design for Optimization
11. Program Cost and Schedule Development Issues
12. Project Management Issues Case Study
13. Implementation Case Studies



# Typical Course Schedule

## **Fall Semester:**

- Geometrical Optics
- Physical Optics
- Engineering Management Elective

## **Spring Semester:**

- Optics and Photonics System Design
- Optomechanical Design and Manufacturing
- Elective 1

## **Summer:**

- On Site Practicum Thesis

## **Fall Semester:**

- Integrated Product and Process Design
- Optical Fabrication and Testing
- Elective 2



# MS/MSE Concentration in Optics and Photonics Technology

## Practicum Opportunities

Advanced Optical Systems (1)

Dynetics, Inc. (1)

Hughes Danbury Optical Systems (2)

MICOM (6)

MSFC (6)

Nichols Research (2)

NIST (5)

ORNL (8)

SCI (1)

Speedring (1)

Total 33



## **SAMPLES OF ON-SITE PRACTICUM**

**NASA/MSFC** - (a) Diamond Turning; (b) Ion Figuring; (c) diffractive Optics; (d) Coherent Optics; (e) Video/Imaging Systems; (f) Optical Design

**MICOM** - (a) Guided Wave Optical Devices; (b) Integrated Optical Components; (c) Electro-Optical Polymer Devices; (d) Microfabrication for Electro-Optical Devices and Integration; (e) Diffractive and Binary Optical Devices

**ORNL** - (a) Evaluation of prototype metrology instruments for optical scatter and figure; (b) interpreting power spectrum measurements of deterministically fabricated surfaces; (c) finite element analysis approaches to distortion-free mounting in fabrication, testing, and end-use; (d) selected topics in single point diamond turning; (e) selected topics in ion beam milling; (f) selected topics in ductile mode grinding of brittle materials; and (g) selected topics in photonics

### **Advanced Optical Systems - Optical Image Processing**

**Dynetics** - Wideband High-Speed Signal Process and Microwave Device Development based on Acousto-Optic Technology

**Hughes Danbury** - (a) White Light Interferometer for Coarse Metrology; (b) Caustic Scanning Interferometer for Testing Aspheric Optics

**Nichols Research** - (a) Passive Ice Detection system for Flight Safety; (b) Advanced Optical Instrumentation

**NIST** - (a) Laser Ranging for Remote Sensing; (b) Ultrafast Lasers; (c) Absolute Cryogenic Radiometry; (d) Parametric Down Conversion; (e) Thermal Imaging

**SCI** - Fiber Position Sensor - Testing of the prototype of a high accuracy position sensor for fiber optic cable winding, perform additional analyses, and make design improvements

**Speedring** - Precision Optical Manufacturing





# MS/MSE Concentration in Optics and Photonics Technology

## Publicity:

Booth at TABES '95

Invited Talk at the 1995 SPIE Annual Meeting,  
1995 International Conference on Education in Optics

Poster Presentation at the NSF/TRP/MET Conference

Presentation at the OSA 1995 Annual Meeting, Forum on Education

Paper accepted at the 1996 Annual Conference of the Graduate Studies of the ASEE

Advertisements in Physics Today & OE Reports

Flyers sent to 140 Student Chapters of OSA & SPS  
98 Industrial and Government Labs

UAH/CAO Home Page



# 1995 - 1996 POMO Student List

<b>Name</b>	<b>Year</b>	<b>EE/PHY</b>	<b>Advisor</b>	<b>PT/FT</b>
Paul Burke	'94	PHY	Dr. Gregory	FT
Jeffrey T. Meier	'94	EE	Dr. Nordin	FT
Stephen W. Berry	'95	PHY	?	PT
Lillian S. Ezell	'95	EE	?	PT
Amy M. Houts	'95	PHY	Dr. Fork	FT
Bryant E. Nulter	'95	EE	?	FT
Napoli K. Oza	'95	EE	?	FT
John E. Reid	'95	PHY	Dr. Emslie	PT
David W. Sparks	'95	EE	Dr. Sing	FT
Howard B. Wingo	'95	EE	Dr. Nordin	PT
Earlie Oliver	'96	EE	?	FT



**Instructor:** Dr. Mustafa A.G. Abushagur  
408 Optics Building  
895-6215 ext. 408

**Textbook:** Saleh and Teich, *Fundamentals of Photonics*, Recommended.

<b>Grades:</b>	Homework	20%
	Midterm	20%
	Term Paper	30%
	Final	30%

## Course Outline:

### 1. Components

- 1.1 Light Sources
- 1.2 Detectors
- 1.3 Modulators
- 1.4 Lenses and Mirrors
- 1.5 Diffractive Optical Elements
- 1.6 Fibers and Fiber Components

### 2. Subsystems

- 2.1 Transmitters
- 2.2 Receivers
- 2.3 Detector Arrays and Drive Electronics
- 2.4 Optical Correlators
- 2.5 Post Processing

### 3. Systems

- 3.1 Telescopes
- 3.2 Optical Pattern Recognition
- 3.3 Adaptive Signal Processing
- 3.4 Laser Radars
- 3.5 Infrared Systems
- 3.6 Fiber Communication Networks
- 3.7 Fiber Imaging
- 3.8 Fiber Sensors



## ***TERM PAPER***

Due 4/3/96

### **I. The term project will consist of two parts:**

- Term paper to be submitted by 4/3/96
- Presentation of the paper on 4/3 and 4/10

### **II. The project is a system design with the following requirements:**

1. Define the specifications of the system
2. Sketch of the system
3. Identify the different components
4. Analyze the system for: power, data rate, resolution, speed, performance, cost, ....
5. Design the system based on performance, cost and reliability.
6. Use off-the-shelf components and specify vendor and part numbers when possible.

### **III. Examples of systems:**

Fiber link

Fiber optic bundle telescope

Acousto-optic Spectrum Analyzer

Optical pattern recognition system

### **IV. Design Teams**

Design teams consist of two students each.





# **OPTICAL AND PHOTONIC SYSTEM DESIGN**

## **EE 570/OSE 570**

### **Spring 1995**

- Number of Students: 8
- Guest Speakers: Professor Russell Chipman  
Dr. Robert Berinato (Dynetics)
- Example Projects: System Design for Phase Matching Laser Arrays  
Fiber Optic Local Area Networks  
Wavefront Splitting Interferometer for LC-SLM  
Characterization  
Supervised Learning Neural Networks Using LC  
Modulators

### **Spring 1996**

- Number of Students: 8
- Guest Speakers: Professor Russell Chipman  
Dr. Robert Berinato (Dynetics)



# OPTICAL AND PHOTONIC SYSTEMS DESIGN

- **Course Outline:**

1. Review of paraxial optics
2. Ray tracing codes
3. Example system design using ray tracing codes
4. Aberration and diffraction calculations
5. Operation and design of acousto-optic and electro-optic modulators
6. Laser and light emitting diode selection
7. Photodetectors and CCD arrays
8. Photodetection noise
9. Signal-to-noise and bit-error-rate calculations
10. Gratings and optical waveguides
11. Fibers and fiber system components (splicers, connectors and couplers)
12. Diffractive and binary optical elements
13. Computer generated holograms and holographic optical elements
14. System design examples:
  - a) Telescopes
  - b) Hybrid optical elements (refractive and diffractive optics)
  - c) Optical pattern recognition systems
  - d) Fiber networks (long-haul, local area networks)
  - e) Fiber sensors
  - f) Adaptive signal processors
  - g) Optical neural networks
  - h) Optical interconnects



# **OPTICAL AND PHOTONIC SYSTEMS DESIGN**

**EE 570/OSE 570**

- ***Objective***

**To teach the student design and analysis of optical and photonic systems and components.**

- ***Course Description***

**Review of paraxial optics, ray tracing codes, aberration and diffraction calculations, acousto-optic and electro-optic modulators, spatial light modulators, fibers, fiber splicers and connectors, grating and diffractive optical elements, laser diodes, light emitting diodes, photodetectors, and CCD arrays, imaging systems, correlators, optical communication networks, and optical signal processing system design.**



# **OPTOMECHANICAL DESIGN AND MANUFACTURING**

**(EE670/PH670)**

## ***COURSE DESCRIPTION:***

- This course covers the practical aspects of optomechanical design, material selection, fabrication and integration of precision optical components and systems for commercial, space and military applications.
- The students are introduced to integrated computer-aided design and analysis tools.
- The course also covers fabrication methods for optical and structural components, including tolerance analysis, machining methods, thermal stabilization, finishing and plating techniques.
- Some special topics including metal optics, diamond machining, and replication methods for low-cost rapid prototyping are also discussed.





# ***OPTOMECHANICAL DESIGN AND MANUFACTURING***

**(EE670/PH670)**

## ***INSTRUCTORS:***

Anees Ahmad and Darell Engelhaupt, Center for Applied Optics, UAH

Plus 4 lectures given by guest lecturers from the industry/government labs.

## ***TEXTS:***

1. Opto-mechanical Systems Design , second edition, by Paul Yoder.  
Published by Marcel Dekker, Inc.
2. Introduction to Optomechanical Design for Mechanical Engineers  
by Daniel Vukobratovich. SPIE Short Course Notes.



# ***OPTOMECHANICAL DESIGN AND MANUFACTURING***

**(EE670/PH670)**

## **TOPICS COVERED:**

**14 weeks**

- |   |         |
|---|---------|
| 1. Optomechanics fundamentals and design principles:                | 2 weeks |
| 2. Optical mounts (mirrors, lenses, prisms, windows, etc.):         | 2 weeks |
| 3. Adjustment mechanisms (linear, rotary and tilt)                  | 1 week  |
| 4. Dimensional Stability, Thermal and Environmental considerations: | 2 weeks |
| 5. Material selection:  | 2 weeks |
| 6. Fabrication methods:   | 2 weeks |



# ***OPTOMECHANICAL DESIGN AND MANUFACTURING***

**(EE670/PH670)**

- |  |                          |
|--|--------------------------|
| <b>7. Special topics: (Tentative)</b>  | <b>2 weeks</b>           |
| <br>   |                          |
| Cryogenic IR System Design   | (Dave Pollack)           |
| Design and fabrication of UVI camera   | (Jim Spann-MSFC)         |
| Design and integration of optical correlators  | (Bob Berinato, Dynetics) |
| Advanced techniques for lens mounting  | (Paul Yoder)             |
| <br>   |                          |
| <b>8. Computer-aided design and analysis project:</b>  | <b>1 week</b>            |
| <br>   |                          |
| Design and analysis of a simple telescope or a collimator including:<br>Ray tracing, optical performance, effects on performance due to<br>manufacturing and assembly tolerances, and environmental effects<br>(temperature, shock and vibrations) |                          |



# ***OPTOMECHANICAL DESIGN AND MANUFACTURING***

**(EE670/PH670)**

## **STUDENT INFORMATION:**

	<b>1995</b>	<b>1996</b>
• Number of students enrolled	4	8
• Students with Physics major	2	2
• Students with ECE major	2	6
• Non-POMO students	2	2
• Students from Industry/Govt.	0	1





## OSE 654 Optical Testing and Fabrication

*Hillman*

### Topics to be covered

- **Optical Bench Measurements**
  - Nodal Slide, focal lengths, cardinal points
- **Component measurements**
  - Radius of curvature, refractive index, surface roughness
- **General Light Field Measurements**
- **Aberrations**
  - Wavefront aberrations, transverse aberrations, MTF
- **Geometrical Tests**
  - Knife-edge, Hartman, Ronchi



## **OSE 654 Optical Testing and Fabrication**

### **Topics to be covered (continue)**

- **Interferometric and Wavefront Tests**
  - Fizeau, Twyman-Green, lateral shearing,
- **Grinding and Polishing**
- **Optical Coatings**
- **Remote Optical Diagnostics**
  - Holographic interferometry, Moire tests



**ISE 570**  
**Integrated Product and Process Design**  
**Fall Semester, 1995**

Dr. Phillip A. Farrington  
Office 221 EB [895-6568]  
Office Hours: Tuesday 9:00am-11:00am and by appointment

**Course Description:**

Introduces the concepts and tools which support integrated product and process design. Particular attention will be paid to multi-functional teams and their value in promoting the concept of life-cycle engineering. Students will also gain experience with tools and technologies which support the IPPD philosophy and are used to address the design-to-cost and performance issues that arise in new product development.

**Text:** Clausing, Don, *Total Quality Development: A Step-By-Step Guide To World-Class Concurrent Engineering*, ASME Press, New York, New York, 1994.

Katzenbach, Jon R., and Douglas K. Smith, *The Wisdom of Teams: Creating the High-Performance Organization*, Harper Business, New York, New York, 1993.

**References:** *Tool and Manufacturing Engineers Handbook, Volume 6, Design for Manufacturability*, Edited by R. Bakerjian.

Pugh, Stuart, *Total Design: Integrated Methods for Successful Product Engineering*, Addison-Wesley Publishing Company, Wokingham, England, 1990.

**Course Requirements and Grading Policy:**

Midterm Exam	100 points
Wisdom of Teams Exam	50 points
Team Project	100 points
Case Study	50 points
<u>Final Exam</u>	<u>100 points</u>
Total Points	400 points

**Late Homework and Make-up exam Policies:**

- 1) Any changes in this syllabus or the grading policy will be announced in class.
- 2) No late homework/lab assignments will be accepted without prior permission. If you must miss a class, you should turn in your homework early.
- 3) Any missed exam will be made up during the final week of classes at my convenience.



**ISE 570**  
**Integrated Product and Process Design**  
**Preliminary Schedule of Topics**  
**Fall Semester, 1995**

Week	Date	Topic
1	8/24	Course Review/IPPD Overview
2	8/31	IPPD Overview/Product Planning & Design
3	9/7	Integrated Product Teams/Product Planning & Design
4	9/14	Empowerment/Product Planning & Design
5	9/22	Team Building/Concept Selection
6	9/28	Subsystem Design
7	10/5	Subsystem Design
8	10/12	Midterm Exam - 2.5 hours
9	10/19	Piece Part Design
10	10/26	System Verification
11	11/2	Developing Production Capabilities
12	11/9	Pilot Production
13	11/16	Wisdom of Teams Exam
14	11/30	Implementation Case Studies
15	12/5	Final Exam - 2.5 Hours





cc: John Dimmock

Paul Burke

## **UAH Practice Oriented M.S. in Optics Degree**

**Paul Burke**

**UAH Practicum**

**Location:** NASA Marshall Space Flight Center

Optics and RF Division -- EB53

Jim Bilbro, Ken Herren, Sandy Montgomery

### **General Perspective**

- Research contract for one year at NASA MSFC
- Power Beaming Project -- High-Power Laser Diode Array
- Create adaptive optic system utilizing optical fibers in IR
- Verify proposed concepts for power beaming to geosynchronous orbit satellites



# **Fiber Optic Phase Modulator for Laser Diode Array**

Program Review -- NASA - MSFC

## **Proposal:**

- Create a system to phase-lock a semi-conductor diode array
- Analyze previous work on this problem
- Demonstrate phase modulation capability for a master-oscillator and power amplifier (MOPA)
- Power Amplifier supplied by Phillips Labs  
Kirtland AFB, New Mexico
- Work to be done with existing MSFC equipment

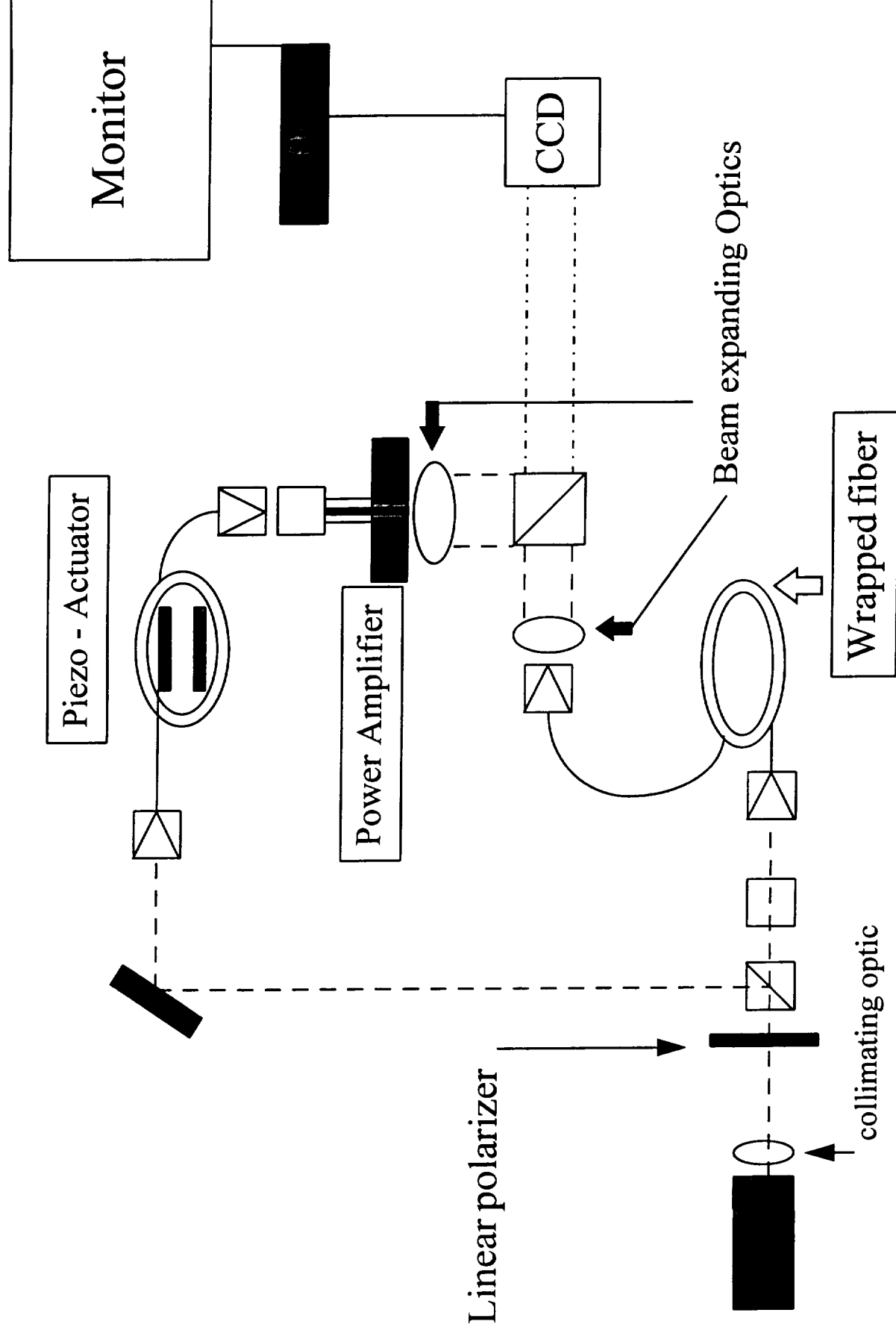


## **Procedure of Research:**

- Analysis of previous system
  - Polarization problems
    - Actuator Problems
- System design and component acquisition
  - Phase Modulator
    - Piezo-Electric actuator - CIR Ltd.
  - Polarization-maintaining fiber - Andrew Corp
  - Semi-conductor Power Amplifier - Phillips Labs



# Phase Modulator System Layout







## **Phase Modulation Concept:**

- Changing the Optical Path Distance (OPD)
  - Stretch optical fiber to increase/decrease OPD
  - Polarization effects. (PM fiber)
- Maintaining phase and mode in amplifier
  - Phase correction made before injection-lock
    - Temperature and drive current
  - Injection-locking with power amplifiers
  - High modulation bandwidth  $> 1 \text{ KHz}$
- Master laser can be split among many power amplifiers in an array



## Phase Modulation Methods

<u>Option</u>	<u>Bandwidth</u>	<u>Location</u>	<u>*</u>
Thermal	Low	Power amplifier	
Current	Medium	Power amplifier	
Fiber (mechanical)	High	Fiber arm	
			<u>*</u>

- Any changes in power amplifier environment will change the gain curve and amplifying efficiency.
- Temperature can be maintained to eliminate thermal effects using thermo-electric cooler ( $\ll \lambda / 10$  drift)
- Drive current can be maintained to within 0.1 mA, making phase drift negligible



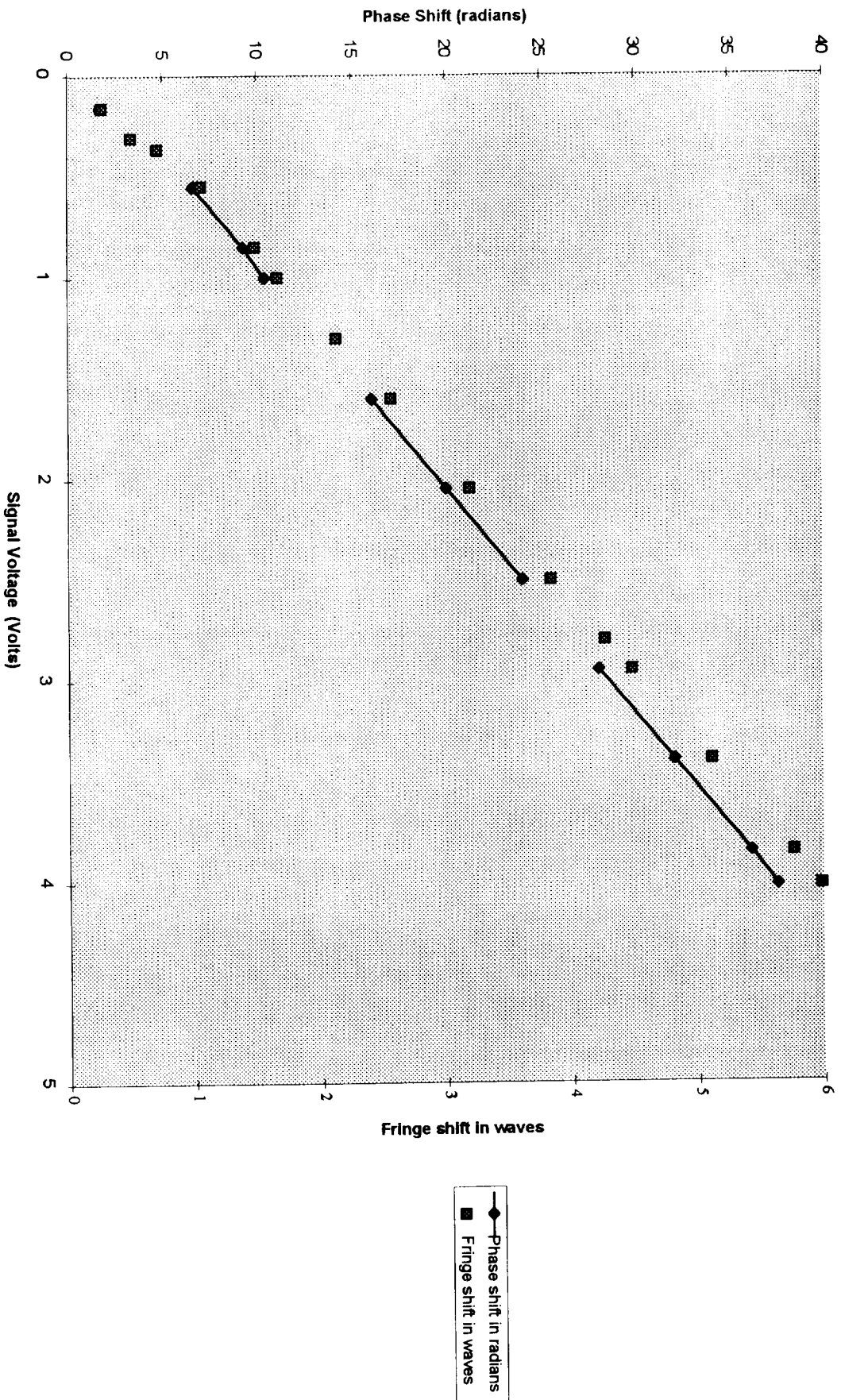
## **Research Work Results**

- Phase Modulation ability
  - Accuracy to  $\pi/8$  ( $\lambda/4$  in fringe pattern)
  - Linear response to signal current
  - Total phase shift possible  $\gg 2\pi$
  - Modulation bandwidth  $> 1$  Khz
- Image processing analysis
  - Video frame grabber and PC set-up
  - Phase modulation with power amplifier in place
  - Demonstration of phase matching



Figure #2

Phase Change caused by Piezo Actuator







# Jeff Meier --- Summer Practicum Description

## I. Introduction

(Name, School History, etc.)

## II. Project Description:

### A. NASA LIDAR Scanning Element

30° Bending of Light Needed

Must Be at least 90% Efficient

Initial Prism Idea

Diffraction Optic Idea

Photorefractive Polymers

### B. Equations Produced From Maxwell's

Eqns.:

Bragg Angle Calculations

Efficiency Equations

### C. Setup:

(Laser split, columnized, and

Recombined as in Young's Double slit)

Coherence Problems

Diffraction Problems

Intensity of Each Arm

Exposure Times

Safety

Film Handling



# Jeff Meier --- Summer Practicum Description

## III. Testing:

4 Different Wavelengths  
(633, 859, 1300, 2000 nM)  
Effects of Baking Film  
Near 100% Efficiency With a HeNe  
Laser  
Efficiency and  $\Delta n$  Relationships  
( $\Delta n$  proportional to  $d/\lambda$ )

## IV. Analysis of Results

Calculate New Thickness  
Order New Film  
Settle for Best Film Available

## V. Final Work to Be Done

Test New Film  
Make Final Optic



## **UAH M.S. Optics Program Review**

### **Student Perspective**

- **Strengths**

- Course selection
- Quality of instructors and material
- Management courses add diversity
- Application to real work

- **Suggestions**

- Incorporation of Lab work (\*\*\*)
- Assistance in Practicum structure
- Scheduling consideration for working students
- Distanced learning possibilities

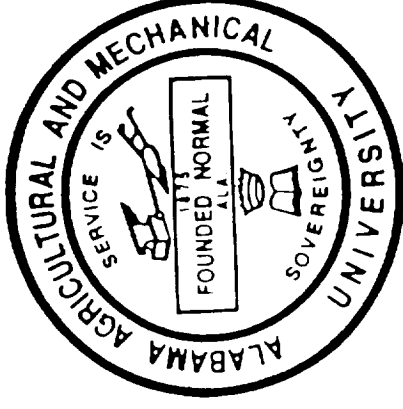


# **MS/MSE Degree Program in Optics and Photonics Technology**

Academic and Research Programs at Alabama A&M University

## **Department of Physics**

R.B. Lal  
Professor of Physics



**Annual Review Meeting  
The University of Alabama in Huntsville  
March 6, 1996**





# *Physics Department Highlights*

---

- *A Dynamic and Progressive Department*
- *14 tenured and 14 research faculty members*
- *Offers B.S. degree in Physics and Applied Physics*
- *M.S. and Ph.D in Materials Science/Optics*
- *Research Projects funded by NASA, NSF, DOD, DOE and private companies*
- *Research Funding: 5.5 million Dollars/year*
- *Every student supported financially*



## **Members of Physics Department**

**M. D. Aggarwal, Ph. D (Crystal Growth and Characterization)**

**R. Bommarreddi, Ph. D (Laser Spectroscopy)**

**H. J. Caulfield, Ph. D (Optical Computing) (University Eminent Scholar)**

**\* A. Darwish, Ph. D (Laser Spectroscopy)**

**\* M. Dokhanian (Optics)**

**\*\* T. Deslis, Ph. D (Optics)**

**\*\* P. Ebert (Optics)**

**K. He, Ph. D (Optics)**

**L. R. Holland, Ph. D (Physics and Material Science)**

**D. Ila, Ph. D (Condensed Matter and Surface Physics)**

**\* G. M. Jenkins, Ph. D (Polymeric Carbon, Carbon & Fiber)**



## **Members of Physics Department - Cont'd**

**\*B. Johnson ( Optical Design, IR Optics)**

**\* J. Kinser, D.Sc (Optical Neural Network)**

**\*N. Kukhtarev, Ph.D (Optics, NLO)**

**R. B. Lal, Ph. D (Crystal growth, Space Experiments, Mat. Sci.)**

**C. T. Lee, Ph. D (Quantum Optics)**

**C. W. Lowe, Ph. D (Materials, Quantum well structures) (Chairperson)**

**\* M. Noginov, Ph. D (Optics)**

**\*\* P. Ruffin, Ph. D (Fiber Optics)**

**A. Sharma, Ph.D (Optics)**

**\* M. Schamschula , Ph.D ( Optical Computing)**



## **Members of Physics Department - Cont'd**

**\*S. Sarkisov, Ph. D (Optical Recording)**

**A. Tan, Ph. D (Atmospheric Physics)**

**P. Venkateswarlu, D. Sc. (Laser Spectroscopy & Nonlinear Optics)**

**A. William, Ph. D (Optics, Director MRCE)**

**J. C. Wang, Ph. D (Mat. Science, Crystal Growth Modeling)**

**\* W. S. Wang, Ph. D (Crystal Growth)**

**W. C. Watson, Ed. D (Science Education)**

**\* H. W. Zhang (Crystal Growth NLO Materials)**

**\* R. Zimmerman, Ph. D (Surface Physics)**

**\* Research Faculty**

**\*\* Adjunct Faculty**





# *Academic Programs*

## *Department of Physics*

---

### *Undergraduate Programs*

#### **B.S. (Applied Physics Option)**

- *Electrical Engineering Option*
- *Mechanical Engineering Option*
- *Civil Engineering Option*
- *Computer Science Option*
- *58 hours General Education, 30 hours Physics, 15 hours of any option, 15 hours Mathematics, and 9 hours of Computer science*

#### ■ ***B.S. Physics with mathematics minor***



# *Academic Programs*

## *Department of Physics*

---

### *Graduate Programs*

#### ■ *M.S. Degree in Applied Physics*

- *Materials Science*
- *Optics/Lasers*

- *Thesis or Non-thesis option*

*At least 12 hours of general courses, 18 hours(non-thesis) and 12 hours (thesis option) of specialized courses(Mat. Sci./Optic*

#### ■ *Ph.D. Degree in Applied Physics*

- *Materials Science*
- *Optics/Lasers*

- *At least 15 hours of general courses, 45 hours of specialized courses and 12 hours of dissertation*



**Courses Offered at Alabama A&M University in the MS/MSE Degree  
Program In Optics and Photonics Technology**

**Electives**

**a. Optical Systems and Engineering:**

**PHY 670 Nonlinear Optics**

**b. Quantum Optics:**

**PHY 660 Quantum Optics**

**c. Optical Signals:**

**PHY 771 Signal Processing**

**d. Optical Communications:**

**PHY 715 Fiber Optics**

**e. Optical Materials:**

**PHY 632 Elements of Materials Science**

**PHY 634 Crystal Physics and Crystal Growth**

**PHY 635 Magnetic and Optical Properties of Materials**

**PHY 735 Materials for Radiation Detectors**



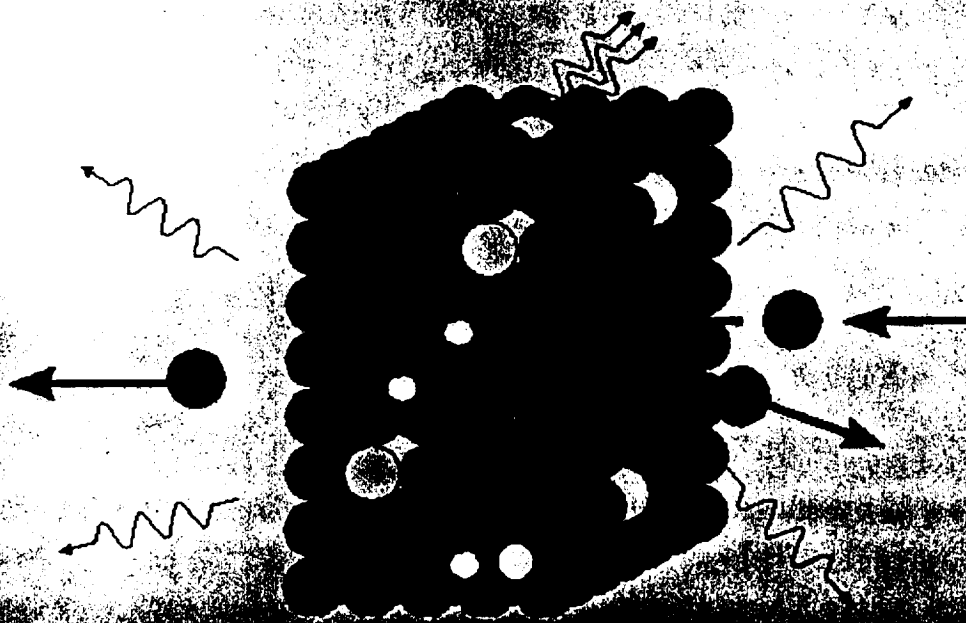
# **NSF- Minority Research Center of Excellence for Nonlinear Optics and Optical Materials**

- o Regional Science Education Technology Transfer Program
- o Growth of Nonlinear Optical Materials
  - Melt growth*
  - a. Czocharalski, Bridgman, Top Seeded Solution Growth  
*Solution growth*
  - b. Aqueous and Organic solutions by temperature lowering
- o Growth and Study of Modified Ferroelectric Films.
- o Diffusion Studies of Semiconductors and other materials and Ion  
implantation of optical fibers.
- o Study of Polymeric Carbon
- o Crystal Growth Modelling
- o Nonlinear Optics
  - Energy upconversion Lasers*
  - Nonlinear Fiber optics: SRS and solitons*
  - Optical phase Conjugation*
  - Parametric Mixing*
  - Inhomogeneous Deformation of Interface Layers*
  - Nonlinear optics in organic systems*
- o Characterization of NLO Materials
  - A. Williams - Director





# *Center for Irradiation of Materials*



*D. ILA, Director*

*Center for Irradiation of Materials  
Alabama A&M University*

*P.O. Box 1447, Normal, AL. 35762-1447*

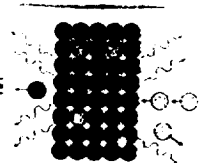
*Phone (205) 851-5866*

*Fax (205) 851-5868*

*Email: ILA@CIM.AAMU.EDU*

*Home Page: HTTP://CIM.AAMU.EDU/*





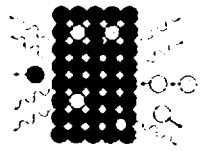
*Services at:*

***Center for Irradiation of  
Materials***

(<http://cim.aamu.edu/>)

- ♦ **Elemental Analysis**
- ♦ **Ion Implantation**
- ♦ **Characterization of Physical  
Properties**
- ♦ **Scanning Single-Event Upset**
- ♦ **Electrical and Optical  
Characterization**





***Projects at:  
Center for Irradiation  
of Materials***

- ♦ Fabrication of Stacked Waveguides in  $\text{LiNbO}_3$
- ♦ Fabrication of Optical Channel Waveguides in GaAs/AlGaAs
- ♦ Ion Beam Fixation of Holographic Patterns in  $\text{LiNbO}_3$
- ♦ Fabrication of Ultra-fast Optical Non-Linearities in Geometrically Shaped Metal Nano-Crystals Confined in Optical Materials
- ♦ Combined Laser, Ion Beam, and Ultrasonic Techniques in Fabricating Nano-Structures



## **CENTER FOR APPLIED OPTICAL SCIENCES (CAOS)**

**Main personnel include the following:**

- \* John Caulfield: rated as "one of America's 10 top scientists" by Bus. Week; winner of Gabor Award and the Vasilov medal. Expertise in Optical Computing and Holography.**
- \* Berry Johnson: former president of SPIE, fellow of OSA and SPIE. Expertise in Infrared and Optical design technology**
- \* Joseph Shamir: former vice president of International commission for Optics, former president of Israel Electro-optic Society Expertise in Holography and Interferometry**
- \* Nikolai Kukhtarev: Expertise in Photo Refractive Theory**



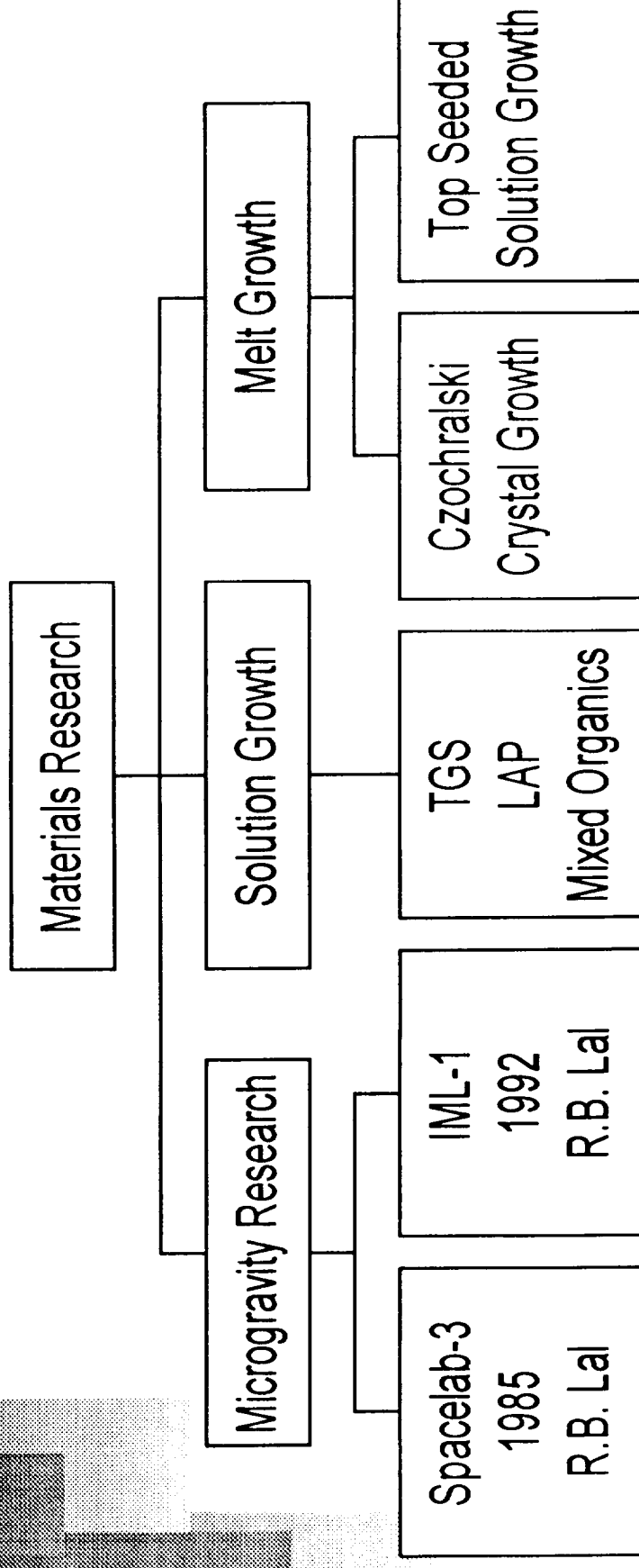


## **Research Capabilities of the Physics Department Alabama A&M University**

- Crystal growth from solution, melt, and vapor of IR, NLO, and photorefractive materials.
- Investigation of Polymeric Carbon and Carbide ware.
- Materials characterization by techniques like, SEM, EPR, RBS, Optical and Electrical methods, etc.
- Surface Diffusion studies by Ion Implantation.
- Crystal Growth Modeling.
- Nonlinear optics in Organic and Photorefractive materials, and Nonlinear Fiber Optics.
- Upconversion Lasers.
- Real-time Interferometry in Photorefractive Materials.
- Integrated Optics in Thin films of Polymeric and Organic materials.
- Optical Phase Conjugation in Photorefractive materials.
- Study of Optical Surfaces and Lenses.
- Squeezed States : Application in Optical Communication.
- Optical Computing, Optical and Optically Assisted Neural Network.
- Planetary and Space Physics

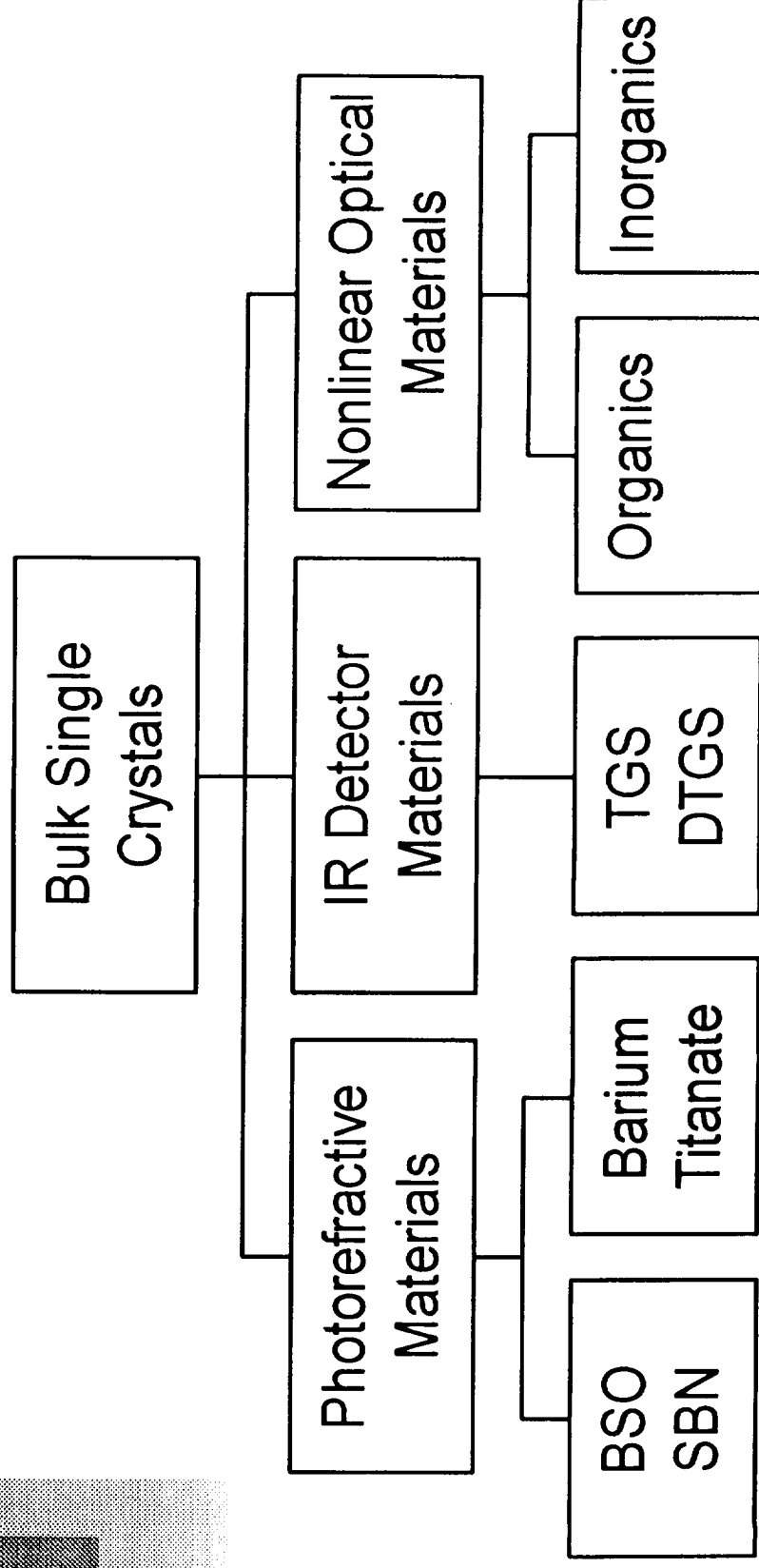


# Materials Science



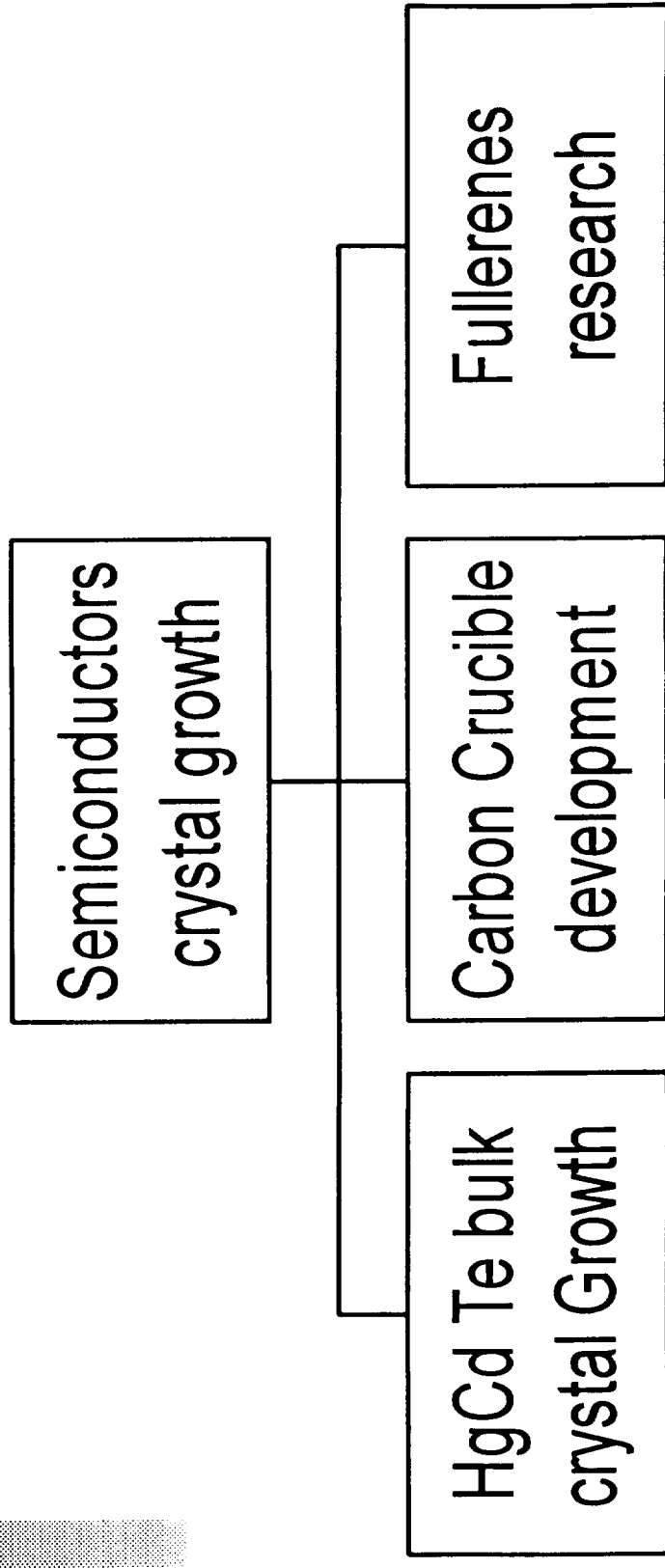


# Materials





# *Materials Research*







# *Crystal Growth Facilities*

---

- *Czochralski Crystal growth systems for inorganic and organic nonlinear optical materials*
- *Bridgman-Stockbarger Crystal Growth systems*
- *Solution Growth Crystallizers*
- *Top Seeded solution growth systems*
- *High temperature RF and Graphite Furnaces*





# *Characterization Facilities*

---

- *Scanning Electron Microscope*
- *Dielectric Constant measuring set up*
- *C-V plotting system*
- *E-beam and thin film evaporators*
- *2 MeV Pelletron Accelerator*
- *Philips X-ray diffraction system*
- *Crystal cutting and polishing*
- *BOMEM FTIR system*



## *Characterization (contd.)*

- *EPR studies in Photorefractive materials*
- *DSC and DTA systems for thermal analysis*
- *SETARAM differential thermal analyzer*
- *Hot Stage microscope for in-situ phase change observation for Ni-based superalloys*
- *Polarizing and metallurgical microscopes*



The background of the slide is a grayscale photograph of a laboratory. On the left, there is a large piece of equipment, possibly a crystal growth furnace or a similar high-temperature apparatus. In the center and right, there are various other pieces of laboratory equipment, including what looks like a vacuum chamber or a similar device, and some smaller instruments on a bench. The overall scene is a typical scientific laboratory environment.

# *Fabrication and Processing*

---

- *Crystal cutting wire and diamond saw*
- *Strausbaug Crystal polishing system*
- *Buehler vibro polisher*
- *E-beam and thin film evaporation*
- *Crystal orienting goniometers*
- *Solid State devices clean room*







# *Materials Science Highlights*

---

- *Spaceflight Experiments on Spacelab-3 and IML-1*
- *Bulk single crystal growth of materials from solution and melt techniques*
- *NSF Minority Center of excellence in Nonlinear Optics and Materials*
- *Research Projects funded by NASA, NSF, DOD, DOE and private companies*
- *Research Funding: 5.5 million Dollars/year*



MS/MSE CONCENTRATION IN OPTICS AND PHOTONICS TECHNOLOGY  
AN INDUSTRIAL PERSPECTIVE

6 MARCH 1996

BOB BERINATO  
DYNETICS, INC.



## OBJECTIVES OF INDUSTRIAL PARTICIPATION

THE OBJECTIVE OF INDUSTRIAL PARTICIPATION IN THE MS/MSE CONCENTRATION IN OPTICS AND PHOTONICS TECHNOLOGY IS TO PROVIDE PERSONNEL AND FACILITIES TO TRAIN THE STUDENTS ENROLLED IN THE PROGRAM

THIS INCLUDES:

- REVIEWING THE CURRICULUM AND COURSE CONTENT TO PROVIDE GUIDANCE ON INDUSTRIAL NEEDS AND DESIRABLE SKILLS
- ASSISTING IN TEACHING THE COURSES BY PROVIDING LECTURES THAT REFLECT PRACTICE-ORIENTED OPTICAL SYSTEM DESIGN AND FABRICATION
- PROVIDING ON-SITE TRAINING TO THE STUDENTS FOR ONE SUMMER OR SEMESTER
- SUPERVISING THE PROJECTS OF THE STUDENTS
- GIVING SEMINARS AND WORKSHOPS ON INDUSTRIAL APPLICATIONS



**INDUSTRIAL PARTICIPANTS**

- |                                       |                              |
|---------------------------------------|------------------------------|
| • ADVANCED OPTICAL SYSTEMS (AOS) +    | DICK HARTMAN, 536-5960       |
| • DYNETICS, INC. +, *                 | BOB BERINATO, 922-9230, X315 |
| • HUGHES DANBURY OPTICAL SYSTEMS +, * | PHIL STAHL, 203-797-6606     |
| • NICHOLS RESEARCH CORP. +, *         | BLAIR BARBOUR, 971-2200      |
| • SCI, INC. +                         | DAVE PORTER, 882-4261        |
| • SPEEDRING, INC. +                   | JOHN CERNOSEK, 737-5200      |

\* PROVIDING IN-KIND MATCHING (NASAMSFC ALSO CONTRIBUTING TO IN-KIND MATCHING)

+ PROVIDING ON-SITE TRAINING OPPORTUNITIES





## ON-SITE TRAINING OPPORTUNITIES

- |                                  |                                       |
|----------------------------------|---------------------------------------|
| • ADVANCED OPTICAL SYSTEMS (AOS) | OPTICAL IMAGE PROCESSING              |
| • DYNETICS, INC.                 | SIGNAL PROCESSING / MICROWAVE DEVICES |
| • HUGHES DANBURY OPTICAL SYSTEMS | METROLOGY AND TESTING                 |
| • NICHOLS RESEARCH CORP.         | OPTICAL INSTRUMENTATION               |
| • SCI, INC.                      | OPTICAL ASSEMBLY AND INSTRUMENTATION  |
| • SPEEDRING, INC.                | PRECISION OPTICAL MANUFACTURING       |
- 
- A VARIETY OF OTHER TOPICS ARE OFFERED BY NASA/MSFC, MICOM, ORNL, AND NIST



---

## **ACHIEVEMENTS TO DATE**

---

- NEW COURSES (OSE/EE/PH 570, 670, 671, AND ISE 570) HAVE BEEN REVIEWED BY INDUSTRY PARTICIPANTS
  - GUEST LECTURERS HAVE TAUGHT COURSE SESSIONS
    - *OSE/EE/PH 570, OPTICAL AND PHOTONIC SYSTEM DESIGN*  
BOB BERINATO (DYNETICS), ACOUSTO-OPTIC DEVICES AND SIGNAL PROCESSING
    - *OSE/EE/PH 670, OPTOMECHANICAL DESIGN AND MANUFACTURING*  
JIM SPANN (MSFC), SPACE SCIENCES LAB UV IMAGER  
DAVE POLLOCK (UAH), TBE CRYOGENIC OPTICS PROGRAM  
BOB BERINATO (DYNETICS), OPTICAL PROCESSOR MECHANICAL DESIGN  
NED BRAGG (OETC), CALIBRATION AND TESTING OF OPTICAL SYSTEMS
    - *ISE 570, INTEGRATED PRODUCTION AND PROCESS DESIGN*  
ED MORRIS (LORAL-VOUGHT, DALLAS), INTEGRATED PRODUCT DEVELOPMENT
  - INDUSTRY PARTICIPANTS HAVE HELPED TO ASSEMBLE THE UAH BROCHURE FOR THE MS/MSE PROGRAM
  - INDUSTRY PARTICIPANTS HAVE HELPED TO PREPARE AND MAN THE UAH OPTICS BOOTH AT THE TABES-95 CONVENTION
  - INDUSTRY PARTICIPANTS HAVE DEFINED ON-SITE TRAINING OPPORTUNITIES, AND STAND READY TO HOST STUDENTS FOR SUMMER TRAINING
-



# **ATTACHMENT 3**



## POMO - Steering Group

### Academic:

Alabama A&M University  
Daryush Ila  
Ravindra Lal

Shoals Community College  
Jim Bonner  
Tommy Howard

University of Alabama in Huntsville  
Mustafa Abushagur  
Anees Ahmad

Russell Chipman  
John Dimmock  
Gordon Emslie  
Darell Engelhaupt  
Phil Farrington  
Don Gregory  
Lloyd Hillman  
Stephen Kowel  
Greg Nordin

### Government (cont'd):

U.S. Army Missile Command  
Miles Holloman  
William C. McCorkle

U.S. Army SSDC  
Russ Alexander  
Richard Curtis

Oak Ridge National Labs  
William Key  
Art Miller

### Industrial:

Advanced Optical Systems, Inc.  
Keith Farr  
Richard Hartman

Boeing  
Monty Offutt  
Ralph Reinhold

### Government:

NASA Marshall Flight Center  
Jim Bilbro  
John Carlisle  
Harry Craft, Jr.  
Sally Little

### Industrial (cont'd):

Mason & Hanger  
Larry Bayer  
Jim Cape

Morgan Research  
James McKee  
Timothy Morgan

Nichols Research Corp.  
Blair Barbour  
Roy Nichols

SCI, Inc.  
Warren Tomme

Speedring, Inc.  
Jack McClanahan  
Anthony Hale

Teledyne Brown Engineering  
Ray Watson  
John Yanosky

### Dynetics, Inc.

Herbert Barnard  
Bob Berinato

Hughes Danbury  
Steven Donley  
Phil Stahl







